TRANSPORTATION PROJECT REPORT

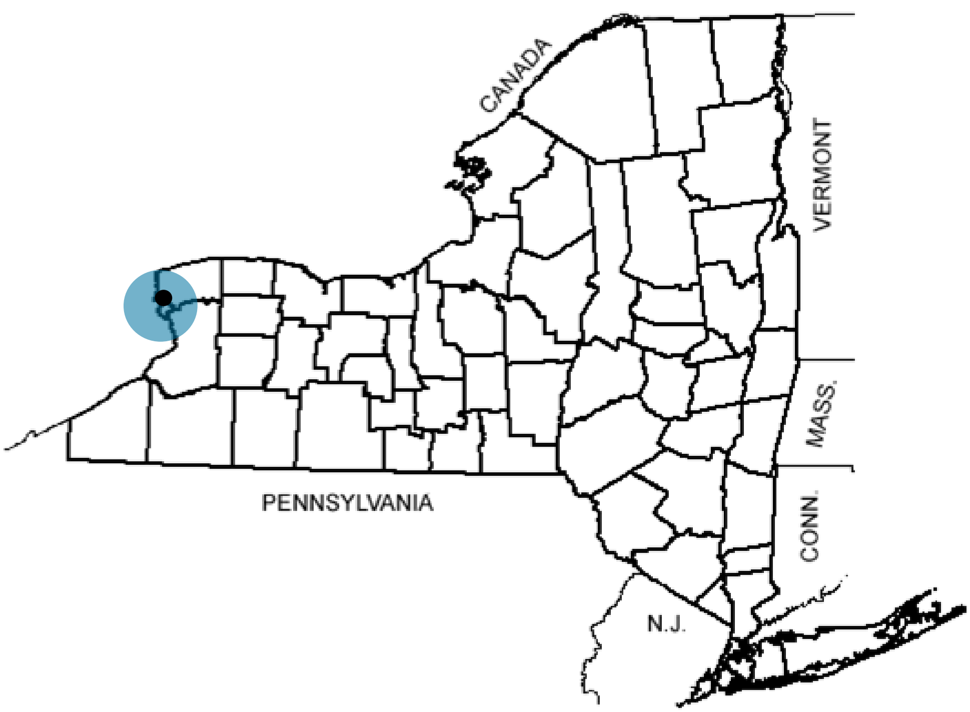
DRAFT DESIGN REPORT / DRAFT ENVIRONMENTAL IMPACT STATEMENT / DRAFT 4(f) EVALUATION

APPENDIX B9

Energy & Greenhouse Gas Analysis

November 2016

PIN 5470.22
NYS Route 198 (Scajaquada Expressway Corridor)
Grant Street Interchange to Parkside Avenue Intersection
City of Buffalo
Erie County



NEW YORK STATE OF OPPORTUNITY. Department of Transportation

ANDREW M. CUOMO
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Commissioner

U.S. Department of Transportation
Federal Highway Administration

APPENDIX B9
Energy

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COVER

EXHIBITS

B9.1 INTRODUCTION

For a description of the project and project alternatives, see Chapters 1 and 3 of this Draft Design Report/Draft Environmental Impact Statement. This appendix provides documentation for the calculation of long-term annual Greenhouse Gas (GHG) emissions based on the proposed action.

B9.1.1 METHODOLOGY

1.1.1 Energy Analysis

Federal Highway Administration 1987 guidelines[1] for preparing environmental impact statements recommend a comparison of direct and indirect energy consumption impacts due to a highway project. The State Energy Plan, adopted in 2002, calls for the State's transportation sector to be more energy efficient and sets goals for reducing consumption.

Since the Build Alternative would alter vehicle speeds and patterns, it has the potential to affect energy consumption. Both the potential direct and indirect energy impacts of the proposed project were analyzed based on guidance and procedures developed by NYSDOT for estimating the energy impacts from construction, maintenance, and operation of transportation projects.

The energy analysis for this project was conducted in accordance with NYSDOT's *Draft Energy Analysis Guidelines for Project-Level Analysis*, dated November 2003. The energy analysis addresses two elements: direct and indirect energy consumption. Direct energy refers to the fuel consumed by vehicles using the highway facility. Indirect energy refers to energy associated with construction and maintenance of the facility. Summary tables of the energy analysis are included in Exhibit A.

1.1.1.1 Direct Energy

Direct energy impact is defined as the energy consumed by vehicles using a facility based on vehicular volumes, weight and average travel speeds. The direct energy analysis for this project was conducted using the U.S. Environmental Protection Agency (USEPA) Motor Vehicle Emissions Simulator (MOVES), Version MOVES2014a.

In accordance with NYSDOT guidance, a mesoscale emissions analysis was conducted for the project's estimated time of completion (ETC) (2020), ETC+10 (2030) and ETC+20 (2040) in association with the air quality analysis. In addition to air quality emissions, MOVES is capable of calculating energy consumption and greenhouse gas emissions based on the project parameters. See Appendix B8 for a detailed description of the air quality analyses.

1.1.1.2 Indirect Energy

The remaining energy impacts are the indirect energy associated with constructing, operating and maintaining a facility. The indirect energy analysis was conducted following the approach outlined in NYSDOT's *Draft Energy Analysis Guidelines for Project-Level Analysis*. Maintenance energy was based on the lane-miles of pavement type for a facility. Construction energy was computed following the Lane-Mile Approach.

1.1.1.2.1 Energy Required for Roadway Maintenance

[1] FHWA Technical Advisory T 6640.8A, October 30, 1987: Guidance for Preparing and Processing Environmental and Section 4(f) Documents

The energy required to operate and maintain each alternative is based on the energy consumed for roadway maintenance (patching, crack sealing, lighting, landscape maintenance, etc.) based on the total lane-miles for each alternative. Annual energy consumption for maintenance per lane mile is provided in the NYSDOT *Draft Energy Analysis Guidelines for Project-Level Analysi*s guidance document.

1.1.1.2.2 Construction Energy

Construction energy is the energy consumed during construction. The indirect energy was calculated using the Lane-Mile Approach, which uses established energy factors per lane-mile for various types of construction activity. The total construction energy consumed is then annualized by dividing total construction energy consumption by 20 years. This analysis was performed by applying the construction factors and construction activities detailed in Exhibit A for the Build Alternative. The No-Build Alternative is assumed to result in no construction costs or related energy consumption.

B9.1.2 Greenhouse Gas Emissions Analysis

The majority of the greenhouse gas emissions associated with the project are in the form of carbon dioxide (CO_2), resulting from the combustion of carbon-based fossil fuels. Fossil fuels account for virtually all energy use by motor vehicles (direct energy), and for virtually all energy embedded in the construction materials and equipment used during construction and maintenance of the roadway (indirect energy). Thus, this analysis of potential emissions of greenhouse gases uses the results from the direct and indirect energy analyses and is reported in CO_2 Equivalents (CO_2e), which is a combined measure of greenhouse gas emissions weighted according to the global warming potential of each gas, relative to CO_2. total carbon emissions. Summary tables of the greenhouse gas emissions analysis are included in Exhibit B.

B9.1.2.1 Greenhouse Gas Emissions Estimates From Direct Energy Consumption

Greenhouse gas emissions from direct energy consumption were calculated by using the MOVES2014a model. Appendix B8 – Air Quality, further describes the MOVES analysis.

B9.1.2.2 Greenhouse Gas Estimates From Indirect Energy Consumption

For CO_2 emissions from indirect energy consumption, it was assumed that the energy consumed during construction and maintenance operations is a result of the combustion of diesel fuel. Therefore, this analysis employed Carbon Emission Coefficients for diesel fuel to calculate the carbon equivalent of CO_2 emissions for each of the project alternatives. These coefficients were provided in NYSDOT's *Draft Energy Analysis Guidelines for Project Level Analysis.* The values were then converted to CO2e.

B9.2 ASSESSMENT OF EFFECTS

B9.2.1 Energy Analysis

B9.2.1.1 Direct Energy

The results of the analysis show that the potential future direct annual energy consumption for the Build Alternative would be slightly less than the energy consumption for the No-Build Alternative. Table B9.2-1 provides a comparison of the vehicle miles of travel (VMT) along the NYS Route 198 Corridor for 2020, 2030 and 2040 for the No-Build and Build Alternatives. Table B9.2-2 provides a summary of the resulting direct energy consumption. The results show that the Build Alternative would require less vehicular energy consumption in the future compared to the No-Build Alternative. These lower values of energy use, despite the higher VMT under the Build Alternative, are mainly due to the emission characteristics of energy versus vehicle speeds in the MOVES emissions model.

Table B9.2-1: Annual Travel Along Project Corridor			
Alternative	Vehicle Miles of Travel		
	2020	2030	2040
No-Build	43,334,342	44,244,215	45,166,927
Build	43,863,753	44,783,496	45,708,878
% Difference	1.2%	1.2%	1.2%

Table B9.2-2: Annual Direct Energy Consumption			
Alternative	Annual Direct Energy Consumption (Million Btu)		
	2020	2030	2040
No-Build	399,334	334,747	317,708
Build	397,782	331,922	313,691
% Difference	-0.4%	-0.8%	-1.3%

B9.2.1.2 Indirect Energy

The indirect energy calculations account for the energy expected to be expended during construction and for maintenance. Between the No-Build and Build Alternatives, the analysis predictably shows that the No-Build would result in the least amount of indirect energy expended since the construction of the Build Alternative would result in higher indirect energy demands. The indirect construction energy was calculated using the Lane-Mile Approach, which uses established energy factors per lane-mile for various types of construction activity. The total construction energy consumed is then annualized by dividing total construction energy consumption by 20 years. The indirect maintenance energy was assumed to be the same for both the Build and No-Build Alternatives. A summary of the indirect energy results is presented in Table B9.2-3.

Table B9.2-3: 2020 Construction Year Indirect Energy Consumption					
Alternative	Lane-Mile Approach			Total Annual Maintenance Energy Consumption	Total Indirect Energy Consumption (Million BTU)
	Construction Energy Consumed Based on Rural Conditions (Million BTU)	Construction Energy Consumed Based on Urban Conditions (Million BTU)	Total Annualized Construction Energy Consumption (Million BTU)		
No-Build	0	0	0	2,895	2,895
Build	138,643	166,371	8,319	2,895	11,214

B9.2.1.3 Total Energy

The total energy for the project includes both the direct and indirect energy consumptions. The results show that the Build Alternative would have higher total energy consumption compared to the No-Build Alternative due to the indirect effects of the construction of the Build Alternative.

Table B9.2-4: Total Estimated Energy Use (Direct and Indirect)			
Alternative	Total Energy Consumption (million BTU) 2020	Total Energy Consumption (million BTU) 2030	Total Energy Consumption (million Btu) 2040
No-Build	402,229	337,642	320,603
Build	408,995	343,136	324,905
% Difference	2%	2%	1%

B9.2.2 Greenhouse Gas Emissions Analysis

B9.2.2.1 CO_2 Emissions Estimates From Direct Energy Consumption

The future direct greenhouse gas emissions for the No-Build Alternative would be slightly higher than that under the Build Alternative in the future. The results of the Direct Greenhouse Gas Energy Analysis are presented in Table B9.3-5.

Table B9.2-5: Annual CO_2e Estimated from Direct Energy Consumption			
Alternative	CO_2e (Tons per Year)		
	2020	2030	2040
No-Build	34,664	29,322	27,993
Build	34,535	29,085	27,655
% Difference	-0.4%	-0.8%	-1.3%

B9.2.2.2 CO_2e Emissions Estimates From Indirect Energy Consumption

The Indirect Greenhouse Gas Energy analysis shows that the No-Build Alternative would result in a lower level of greenhouse gas emissions compared to the Build Alternative. As stated above, the construction work for the Build Alternative would contribute to higher indirect energy requirements, and therefore, higher predicted emissions of greenhouse gases compared to the No-Build Alternative. A summary of the estimated CO_2e emissions from indirect energy consumption are presented in Table B9.2-6.

Table B9.2-6: CO_2 Emissions Estimated from Indirect Energy Consumption			
Alternative	CO_2e (Tons per Year)		
	2020	2030	2040
No-Build	233	233	233
Build	903	903	903

(1) Construction energy and therefore carbon emissions are analyzed over 20 years.

B9.2.2.3 Annual CO_2e Emissions Estimated For The Project

Total carbon emissions in 2020, 2030 and 2040 for the project are presented in Table B9.2-7. The analysis shows that the Build Alternative would result in 1-2% higher emissions compared to that under the No-Build Alternative.

Table B9.2-7: Total Annual CO_2e Emissions Estimated			
Alternative	CO_2e (Tons per Year)		
	2020	2030	2040
No-Build	34,987	29,555	28,226
Build	35,438	29,988	28,558
% Difference	2%	2%	1%

B9.3 MITIGATION

The Build Alternative improves operating efficiency of the project corridor, thereby reducing the direct energy and greenhouse gas emissions associated with the project corridor. Due to the indirect energy used during and embedded in the construction, the long-term annualized energy consumed and greenhouse gases emitted are higher under the Build Alternative as compared to that under the No-Build Alternative. A number of measures would be considered during construction to help minimize the amount of energy consumption and greenhouse gas emissions, such as: the use of low emission diesel vehicles, use of biodiesel fuels, limiting the unnecessary idling of vehicles, keeping well maintained equipment, local materials sourcing, and the use of sustainable construction materials.

50 MPH CONDITIONS WITHOUT PROJECT

In May 2015, the Governor of New York State directed NYSDOT to reduce the posted speed limit along the Scajaquada Expressway from 50 mph to 30 mph. This speed limit change was implemented independent from the current action. However, for the purpose of evaluating cumulative effects, the 50 mph conditions without the proposed project were evaluated. The 50 mph conditions reflect data that were collected before the speed limit was changed to 30 mph, lanes were narrowed, and stop signs were installed on ramp approaches. These changes resulted in an approximate diversion of 20% of the traffic volume from the 50 mph conditions (see Chapter 3 of this DEIS).

The following tables show the direct energy and total energy emissions for the 50 mph conditions without the project. Summary tables of the evaluation are included in Exhibit C.

Table B9.4-1: Total Energy Consumption for 50 mph Conditions without Project					
Year	Vehicle Miles of Travel	Total Direct Energy Consumption (million Btu)	Total Indirect Energy Consumption		Total Roadway Project Energy Consumption (MBtu)
			Maintenance Energy Consumption (million Btu)	Construction Energy Consumption (Btu)	
2020	54,186,289	458,191	2,895	0	461,086
2030	55,278,368	382,994	2,895	0	385,889
2040	56,361,650	363,392	2,895	0	366,287

Table B9.4-2: Total Carbon (CO_2) Emissions Estimated for 50 mph Conditions without Project			
	2020	**2030**	**2040**
Carbon (CO_2) Emissions Estimated from Direct Energy Consumption (Tons per Year)	39,647	33,411	31,867
Carbon (CO_2) Emissions Estimated from Indirect Energy Consumption (Tons per Year)	233	233	233
Total Carbon (CO_2) Emissions Estimated (Tons per Year)	39,880	33,644	32,100

EXHIBIT A

ENERGY ANALYSIS

SCAJAQUADA CORRIDOR DIRECT ENERGY						
	ETC		ETC+10		ETC+20	
	No Build	Build	No Build	Build	No Build	Build
VMT	43,334,342	43,863,753	44,244,215	44,783,496	45,166,927	45,708,878
Energy (Joules)	421,319,857,000,000	419,682,709,000,000	353,177,031,000,000	350,196,793,000,000	335,199,951,000,000	330,961,878,000,000
Energy (MBTU/year)	399,334	397,782	334,747	331,922	317,708	313,691

Direct Energy values obtained from air quality analysis, see Appendix B8. Analysis conducted in MOVES14a.

SCAJAQUADA CORRIDOR					
INDIRECT ENERGY					
ROADWAY MAINTENANCE					
Pavement Type	**Annual Maintnance Energy Consumption (Btu/lane-mi)**	**Area Type**	**Total Lane Miles**	**Total Annual Maintenance Energy Consumption (Btu/yr)**	**Total Annual Maintenance Energy Consumption (Mbtu/yr)**
Asphalt Concrete	1.776E+08	Urban	16	2.895E+09	2,895

SCAJAQUADA CORRIDOR INDIRECT ENERGY ROADWAY CONSTRUCTION LANE-MILE APPROACH									
	From STA	**To STA**	**Length (m)**	**Length (miles)**	**# Lanes**	**Lane-Miles**	**Type of Work**	**Construction Energy Consumed per Rural[a]-Lane-Mile (10^9 Btu/mi)**	**Construction Energy Consumed (BTU)**
EB 198	EB 10+478	EB 10+773	293	0.18	2	0.36	Reconstruction	5.2	1,893,442,321
EB 198 TO ROUNDABOUT	EB 10+773	GSE 1+000	95	0.06	3	0.18	Reconstruction	5.2	920,872,118
Roundabout	GR 1+000	GR 1+040	150	0.09	1	0.09	New construction	12.7	1,183,712,136
EB 198	EB 10+900	EB 12+385	1485	0.92	2	1.85	Reconstruction	5.2	9,596,456,813
EB 198	EB 12+385	EB 13+120	738	0.46	2	0.92	Reconstruction	5.2	4,769,148,234
EB 198	EB 13+120	EB 13+212	89	0.06	3	0.17	Reconstruction	5.2	862,711,774
EB 198	EB 13+212	EB 13+910	692	0.43	2	0.86	Reconstruction	5.2	4,471,884,252
EB 198	EB 13+910	EB 13+975	67	0.04	3	0.12	Reconstruction	5.2	649,457,178
EB 198	EB 13+975	EB 14+130	155	0.10	4	0.39	Reconstruction	5.2	2,003,300,749
EB 198	EB 14+130	EB 14+200	72	0.04	3	0.13	Reconstruction	5.2	697,924,132
EB 198	EB 14+200	EB 14+340	136	0.08	4	0.34	Reconstruction	5.2	1,757,734,851
EB 198	EB 14+340	EB 14+505	167	0.10	3	0.31	Reconstruction	5.2	1,618,796,250
							Reconstruction		
WB 198	WB 10+478	WB 11+785	1311	0.81	2	1.63	Reconstruction	5.2	8,472,023,489
WB 198	WB 11+785	WB 11+910	122	0.08	3	0.23	Reconstruction	5.2	1,182,593,668
WB 198	WB 11+910	WB 12+395	486	0.30	2	0.60	Reconstruction	5.2	3,140,658,593
WB 198	WB 12+395	WB 13+240	844	0.52	2	1.05	Reconstruction	5.2	5,454,147,845
WB 198	WB 13+240	WB 13+400	160	0.10	4	0.40	Reconstruction	5.2	2,067,923,354
WB 198	WB 13+400	WB 13+790	388	0.24	2	0.48	Reconstruction	5.2	2,507,357,066
WB 198	WB 13+790	WB 13+860	72	0.04	3	0.13	Reconstruction	5.2	697,924,132
WB 198	WB 13+860	WB 13+935	76	0.05	2	0.09	Reconstruction	5.2	491,131,796
WB 198	WB 13+935	WB 14+140	202	0.13	3	0.38	Reconstruction	5.2	1,958,064,925
WB 198	WB 14+140	WB 14+270	129	0.08	5	0.40	Reconstruction	5.2	2,084,079,005
WB 198	WB 14+270	WB 14+320	54	0.03	4	0.13	Reconstruction	5.2	697,924,132
WB 198	WB 14+320	WB 14+508	184	0.11	3	0.34	Reconstruction	5.2	1,783,583,892
Grant Street East Connector	GSE 1+00	GSE 1+074	75	0.05	3	0.14	Relocation	10.5	1,467,989,460
Grant Street West Connector	GSW 1+00	GSW 1+065	62	0.04	2	0.08	Relocation	10.5	809,025,302
Ramp DC	DC 1+000	DC 1+160	158	0.10	5	0.49	New construction	12.7	6,234,217,250
Ramp L	L 1+010	L 1+070	61	0.04	1	0.04	Reconstruction	5.2	197,098,945
Iroquois Connector	IC 1+000	IC 1+053	50	0.03	3	0.09	New construction	12.7	1,183,712,136
Iroqouis Connector	IC 1+053	IC 1+077	30	0.02	2	0.04	New construction	12.7	473,484,854
Grant Street North Connector	GN 1+220	GN 1+135	84	0.05	2	0.10	Relocation	10.5	1,096,098,797
Grant Street North Connector	GN 1+135	GN 1+070	66	0.04	3	0.12	Relocation	10.5	1,291,830,725
Parkside Ramp	P 1+040	WB 14+100	35	0.02	1	0.02	Reconstruction	5.2	113,089,558
Agassai	M 1+008	M 1+063	55	0.03	3	0.10	Reconstruction	5.2	533,136,490
Parkside	P 1+008	P 1+100	59	0.04	4	0.15	Reconstruction	5.2	762,546,737
Parkside	P 1+100	P 1+170	73	0.05	3	0.14	Reconstruction	5.2	707,617,523
Humboldt Parkway	HP 1+138	HP 1+010	130	0.08	1	0.08	Reconstruction	5.2	420,046,931
Ramp from Parkside	P 1+140	P 1+040	98	0.06	1	0.06	Reconstruction	5.2	316,650,764
Delaware North	DN 1+010	DN 1+095	85	0.05	2	0.11	Reconstruction	5.2	549,292,141
Delaware North	DN 1+095	DN 1+175	84	0.05	3	0.16	Reconstruction	5.2	814,244,820
Delaware North	DN 1+175	DN 1+395	217	0.13	2	0.27	Reconstruction	5.2	1,402,310,524
Delaware North	DN 1+395	DN 1+442	50	0.03	3	0.09	Reconstruction	5.2	484,669,536
Delaware South	DS 1+438	DS 1+345	88	0.05	2	0.11	Reconstruction	5.2	568,678,922
Delaware South	DS 1+442	DS 1+295	52	0.03	3	0.10	Reconstruction	5.2	504,056,317
Delaware South	DS 1+295	DS 1+170	130	0.08	4	0.32	Reconstruction	5.2	1,680,187,725
Delaware South	DS 1+170	DS 1+010	154	0.10	2	0.19	Reconstruction	5.2	995,188,114
Iroquois Drive	ID 1+180	ID 1+220	40	0.02	2	0.05	Reconstruction	5.2	258,490,419
Iroquois Drive	ID 1+180	ID 1+030	152	0.09	3	0.28	Reconstruction	5.2	1,473,395,389
Nottingham Terrace	NT 1+010	NT 1+112	112	0.07	3	0.21	Reconstruction	5.2	1,085,659,761
Grant Street	G 1+210	G 1+270	56	0.03	3	0.10	Reconstruction	5.2	542,829,880
Grant Street	G 1+270	G 1+350	105	0.07	4	0.26	Reconstruction	5.2	1,357,074,701
Grant Street	G 1+350	G 1+425	53	0.03	5	0.16	Reconstruction	5.2	856,249,514
Grant Street	G 1+425	G 1+465	43	0.03	4	0.11	Reconstruction	5.2	555,754,401
New Elmwood Connector Street	EC 1+005	EC 1+060	55	0.03	4	0.14	Major widening	5	683,508,320
New Elmwood Connector Street	EC 1+060	EC 1+180	121	0.08	5	0.38	Major widening	5	1,879,647,880
Bridges									
Grant Street Connector	GN 1+175	GN 1+205	30	0.02	2	0.04	New Bridges	192	7,158,196,224
Buff State Ped Bridge	WB 11+420		27	0.02	1	0.02	New Bridges	192	3,221,188,301
Elmwood Connector	EC 1+075	EC 1+125	50	0.03	5	0.16	New Bridges	192	29,825,817,600
Mirror Lake Ped Bridge			30	0.02	1	0.02	New Bridges	192	3,579,098,112
Main Line Bridge	WB 12+298	WB 12+325	27	0.02	4	0.07	Minor rehabilitation	11.91	799,257,347
Lincoln Pkwy			43	0.03	1	0.03	Minor rehabilitation	11.91	318,222,833
Delaware Ave	EB 13+30	EB 13+080	50	0.03	4	0.12	Minor rehabilitation	11.91	1,480,106,198

Total Construction Energy Consumed Based on Rural Conditions	138,642,523,157	BTU
	x120%	
Total Construction Energy Consumed Based on Urban Conditions	166,371,027,788	BTU
Total Annualized (Over 20 yrs) Construction Energy Consumption	**8,318,551,389**	**BTU/yr**
	8,319	**MBTU/yr**

SCAJAQUADA CORRIDOR						
TOTAL ROADWAY PROJECT ENERGY CONSUMPTION						
Alternative	**Total Annual Direct Energy Consumption (Btu/yr)**	**Total Annual Indirect Energy Consumption**		**Total Roadway Project Energy Consumption (Btu/yr)**	**Total Roadway Project Energy Consumption (Mbtu/yr)**	**% Difference**
		Maintenance Energy Consumption (Btu/yr)	**Construction Energy Consumption* (Btu/yr)**			
ETC						
No Build	399,334,122,902	2,894,880,000	0	402,229,002,902	402,229	
Build Alternative	397,782,000,000	2,894,880,000	8,318,551,389	408,995,431,389	408,995	2%
ETC+10						
No Build	334,747,193,991	2,894,880,000	0	337,642,073,991	337,642	
Build Alternative	331,922,473,751	2,894,880,000	8,318,551,389	343,135,905,140	343,136	2%
ETC+20						
No Build	317,708,211,957	2,894,880,000	0	320,603,091,957	320,603	
Build Alternative	313,691,294,320	2,894,880,000	8,318,551,389	324,904,725,710	324,905	1%

*Annualized over 20 years.

EXHIBIT B

GREENHOUSE GAS ANALYSIS

SCAJAQUADA CORRIDOR		
DIRECT ENERGY		
GREENHOUSE GAS EMISSIONS - CO_2e		
Alternative	**Total Future Year CO2e* (tons/year)**	**% Difference**
ETC		
No Build	34,664	
Build	34,535	-0.4%
ETC+10		
No Build	29,322	
Build	29,085	-0.8%
ETC+20		
No Build	27,993	
Build	27,655	-1.2%

*CO2e values obtained from MOVES2014a model

SCAJAQUADA CORRIDOR							
INDIRECT ENERGY							
GREENHOUSE GAS EMISSIONS - CO_2e							
Alternative	Total Future Year Indirect Energy Consumption** (Btu/yr)	Carbon Emission Coefficient (million metric tons of carbon/quadrillion Btu)*	C Emitted w/ 100% oxidation (Metric Tons/yr)	Estimate Fraction of Carbon Oxidized	Total C Emitted (Metric Tons/yr)	Total C Emitted (Tons/yr)	**Total Annual CO_2e (tons/yr)**
No Build	2,894,880,000	19.95	57.8	0.99	57.2	63	**233**
Build	11,213,431,389	19.95	223.7	0.99	221	244	**903**

* it can be assumed that the energy consumed during construction and maintenance operations is the result of the combustion of diesel fuel.
**Annualized over 20 years.

SCAJAQUADA CORRIDOR				
TOTAL GREENHOUSE GAS EMISSIONS - CO_2e				
Alternative	**Total Annual Direct CO2e (tons/year)**	**Total Annual Indirect CO2e (tons/year)**	**Total CO2e (tons/year)**	**% Difference**
ETC				
No Build	34,664	233	34,897	2%
Build Alternative	34,535	903	35,438	
ETC+10				
No Build	29,322	233	29,555	1%
Build Alternative	29,085	903	29,988	
ETC+20				
No Build	27,993	233	28,226	1%
Build Alternative	27,655	903	28,558	

EXHIBIT C

50 MPH WITHOUT PROJECT ENERGY AND GREENHOUSE GAS ANALYSIS

SCAJAQUADA CORRIDOR			
DIRECT ENERGY			
	ETC	**ETC+10**	**ETC+20**
	50 mph	**50 mph**	**50 mph**
VMT	54,186,289	55,278,368	56,361,650
Energy (MBTU/year)	458,191	382,994	363,392

SCAJAQUADA CORRIDOR					
TOTAL ROADWAY PROJECT ENERGY CONSUMPTION					
Condition	**Total Annual Direct Energy Consumption (Btu/yr)**	**Total Annual Indirect Energy Consumption**		**Total Roadway Project Energy Consumption (Btu/yr)**	**Total Roadway Project Energy Consumption (Mbtu/yr)**
		Maintenance Energy Consumption (Btu/yr)	**Construction Energy Consumption* (Btu/yr)**		
ETC					
50 mph	458,191,000,000	2,894,880,000	0	461,085,880,000	461,086
ETC+10					
50 mph	382,994,000,000	2,894,880,000	0	385,888,880,000	385,889
ETC+20					
50 mph	363,392,000,000	2,894,880,000	0	366,286,880,000	366,287

*Annualized over 20 years.

SCAJAQUADA CORRIDOR	
DIRECT ENERGY	
GREENHOUSE GAS EMISSIONS - CO2e	
Condition	**Total Future Year CO2e* (tons/year)**
ETC	
50 mph	39,647
ETC+10	
50 mph	33,411
ETC+20	
50 mph	31,867

*CO2e values obtained from MOVES2014a model

SCAJAQUADA CORRIDOR							
INDIRECT ENERGY							
GREENHOUSE GAS EMISSIONS - CO_2e							
Condition	Total Future Year Indirect Energy Consumption* (Btu/yr)	Carbon Emission Coefficient (million metric tons of carbon/quadrillion Btu)*	C Emitted w/ 100% oxidation (Metric Tons/yr)	Estimate Fraction of Carbon Oxidized	Total C Emitted (Metric Tons/yr)	Total C Emitted (Tons/yr)	**Total Annual CO_2e (tons/yr)**
50mph	2,894,880,000	19.95	57.8	0.99	57.2	63	**233**

*Annualized over 20 years

SCAJAQUADA CORRIDOR			
TOTAL GREENHOUSE GAS EMISSIONS - CO_2e			
Alternative	**Total Direct CO2e (tons/year)**	**Total Indirect CO2e (tons/year)**	**Total CO2e (tons/year)**
ETC			
50 mph	39,647	233	39,880
ETC+10			
50 mph	33,411	233	33,644
ETC+20			
50 mph	31,867	233	32,100